Disinfection of Treated Wastewater

Introduction:

Treated wastewater from Sewage treatment plant is discharged into river or open land, in many cases it is reused in industrial process also. Raw sewage itself contains pathogens, which is treated with aerobic or anaerobic process. These processes involve treatment done by microorganisms. In this way, the treated wastewater from sewage treatment plant or biological process of effluent treatment plants are having contamination of microorganisms. Thus, before discharging such treated wastewater into the environment, it must be disinfected.

Components/ Processes involved in Disinfection:

Disinfection of treated wastewater can be achieved using three methods:

- Chemical disinfection
    - It utilizes disinfection chemicals viz. chlorine, ozone etc
- Physical disinfection
    - It utilizes physical methods viz. ultraviolet radiation, microfiltration
- Biological disinfection
    - It utilizes biological process viz. detention lagoons

Brief Description of each component /process:

- Chemical disinfection

  Process in Brief: Chemicals such as chlorine gas, monochloramine, Ozone, Chlorine Dioxide, hydrogen peroxide (with or without ozone) are used. These chemicals are mixed with diffusion system with stored or flowing wastewater. Adequate contact time is provided so that these chemicals reacts properly with wastewater.

    - Chlorine: Chlorine remains the most widely used disinfectant chemical in drinking water treatment for both primary disinfection of treated water and for the maintenance of a residual in distribution systems. It is also commonly used in the oxidation and removal of iron and manganese in water treatment upstream of disinfection.
    - Monochloramine: Monochloramine is formed when ammonia and chlorine are dosed, and react, under well controlled conditions. The process is known generically as "chloramination". Good process control is essential to prevent the formation of strong tastes and by-products. The disinfection capability of monochloramine is poor compared with chlorine, and it is generally used to provide a disinfectant residual or preservative, during distribution, rather than being used for primary disinfection.

- Ozone: Ozone is a powerful disinfectant compared with either chlorine or chlorine dioxide. It is the only chemical that can provide effective inactivation of either *Giardia* or *Cryptosporidium* at dose levels not much greater than those used routinely for water treatment. It is, however, an expensive disinfection technology in terms of capital and operating costs.
- Chlorine dioxide: Chlorine dioxide is a more powerful disinfectant than chlorine, and the pure chemical does not form THMs by reaction with humic substances. Chlorine dioxide is generated on demand, usually by reaction between sodium chlorite and hydrochloric acid; it can also be made by reaction between sodium chlorite and chlorine, although careful control is required to ensure by-product formation is small. Chlorine dioxide is likely to be substantially more expensive than chlorine.
- Hydrogen Peroxide: The use of hydrogen peroxide in the treatment of potable water has been limited. This is in part due to its instability in storage and the difficulty in preparing concentrated solutions. It is a strong oxidizing agent, but a poor disinfectant achieving little or questionable inactivation of bacteria and viruses. Hydrogen peroxide can be stored onsite but is subject to deterioration with time and is a hazardous material requiring secondary containment for storage facilities. Although of little value itself, hydrogen peroxide has been used in conjunction with other disinfectants to achieve improved oxidation of organic matter. Its use with ozone and ultraviolet light produces increased concentrations of hydroxyl radicals. These are short-lived, very strongly oxidizing chemical species, which react with the organic matter.

- Physical disinfection
  - Ultraviolet radiation: The disinfection of treated wastewater via ultraviolet (UV) radiation is a physical process that principally involves passing a film of wastewater within close proximity of a UV source (lamp). The efficiency of UV disinfection depends on the physical and chemical water quality characteristics of the wastewater prior to disinfection. With a better quality of wastewater comes a more efficient UV disinfection process. The advantage of the UV disinfection process is that it is rapid and does not add to the toxicity of the wastewater. There have been no reports of byproducts produced from UV disinfection that adversely impact on the receiving environment. UV disinfection does not result in a lasting residual in the wastewater. This is a disadvantage when wastewater must be piped or stored over significant distances and time (particularly relevant to reuse schemes) as re-growth of the microbial population is considered a risk.
  - Membrane filtration: Membrane technologies disinfect treated wastewater by physically filtering out microorganisms. This disinfection process does not require the addition of reactive chemicals and as such, no toxic disinfection by-products are produced.

    Key membrane technologies include: • reverse osmosis; • ultrafiltration; • nanofiltration; and • microfiltration. Microfiltration is the most commercially viable technology for the disinfection of treated wastewater. The wastewater passes through membrane fibres, hollow cylinders permeated with millions of microscopic pores. These pores allow wastewater to flow through the same fibres that act as a physical barrier to particles and microorganisms.

- Biological disinfection
  - Lagoons: The storage of secondary treated wastewater in pondage systems (nominally 30 days) allows natural disinfection to take place before discharging or reusing the treated wastewater.

Pros and Cons of each technology:

Disinfections is needed not at the system discharge point stage (primary disinfection), but also need to sustain during distribution or discharge system of treated wastewater (secondary disinfection). Advantages and limitation of each treatment process is provided for both scenarios in following table:

A) Advantages/limitations of primary disinfection systems

Process	**Advantages**	**Limitations**
Chlorination	Well understood disinfectant capability. Established dosing technology.	Chlorination by-products and taste and odour issues can affect acceptability. Ineffective against *Cryptosporidium*.
Chloramination	No significant by-product issues. Generally less taste and odour issues than chlorine.	Considerably less effective than compared with chlorine. Not usually practical as a primary disinfectant.
Ozone	Strong oxidant and highly effective disinfectant compared with chlorine. Benefits of destruction of organic micropollutants (pesticides, taste and odour compounds).	Bromate by-product and increased assimiable organic carbon (AOC) can impact on re-growth in distribution. Complex, energy intensive and expensive equipment compared with chlorination. Residual insufficiently long lasting for distribution.
Chlorine dioxide	Can be more effective than chlorine at higher pH, and less taste and odour and by-product issues.	Weaker oxidant than ozone or chlorine. Dose limited by consideration of inorganic by products (chlorate and chlorite).
UV	Generally highly effective for protozoa, bacteria and most viruses and particularly for *Cryptosporidium*. No significant by product implications.	Less effective for viruses than chlorine. No residual for distribution.
Membrane Filtration	Microfiltration efficiently reduces particulates, bacteria, and a range of	Potentially high capital costs, the resultant concentrated backwash with significant

	viruses, algae and protozoans, giving this method an advantage over other technologies	microbial contamination, and the handling and management of contaminated chemicals produced by periodic cleaning of the membranes.
Biological disinfection (Lagoons)	Natural disinfection can occur via sunlight and/or natural microbial die-off.	The ability of ponds to remove or reduce the number of pathogens depends on such factors as the load of incoming solids and microorganisms, temperature, sunlight and pond design related to detention time

B) ***Advantages/limitations of secondary disinfection systems (i.e. Maintaining residual in distribution)***

Process	**Advantages**	**Limitations**
Chlorination	Stable residual in clean networks. Potential for using chlorine for both primary disinfection and distribution, makes for straightforward application.	By-product formation during distribution. Loss of residual in distribution systems with long residence times.
Chloramination	Stable residual with no significant by product issues. Generally lower rate of taste and odour complaints than for chlorine.	Needs effective control of process to avoid taste and odour due to either dichloramine or trichloramine. Mixing with non-chloraminated supplies in network can cause taste and odour issues.
Chlorine dioxide		Limited by consideration of inorganic by product formation (chlorite and chlorate)
Ozone and Hydrogen peroxide	Nil	The low solubility of ozone in water is the main factor that greatly reduces its disinfection capacity, and any ozone residual produced rapidly dissipates because of its reactive nature. The absence of a lasting residual may also be a disadvantage as this may allow possible microbial re-growth and make it difficult to measure the efficiency of the disinfection process.

Reference:

- Water treatment manual – disinfection, Environmental Protection Agency, Ireland
- US Environmental Protection Agency